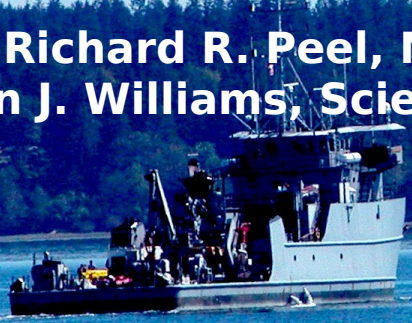
New Technologies For Improved Operational Testing Of Unmanned Underwater Vehicles

By: Richard R. Peel, Naval Undersea Warfare Center (NUWC) Di
Brian J. Williams, Science Applications International Corporation



NDIA 20th Annual Test & Evaluation Conference & Exhibition

March 3, 2004

NUTEC National UUV Test & Evaluation Center

nd

Presented By:
Richard R. Peel
NUTEC Project Manager
NUWC Division Keyport
E-Mail: NUTEC@kpt.nuwc.navy.mil

http://www-keyport.kpt.nuwc.navy.mil/NUTEC/NUTEC_Home.htm

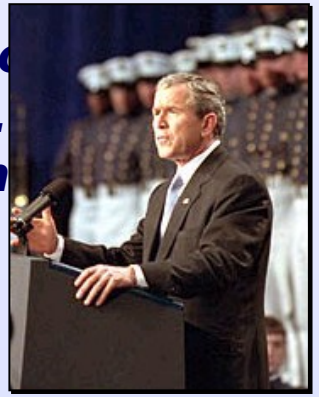
BRIEFING TOPICS

- **New T&E Requirements For Navy UUV Programs**
- **Shared UUV T&E and Training Support Concept**
- **T&E Challenges In A Spiral Development Environment**
- **New UUV T&E Technologies Demonstrated For Spiral Development Testing At *AUV Fest 2003***
- **Follow-On UUV T&E Support For Combined Joint Fleet Exercise (CJTFEX) 04-2**
- **The Way Ahead – Advancing Navy UUV T&E Capabilities To Support Spiral Development & Operational Testing**

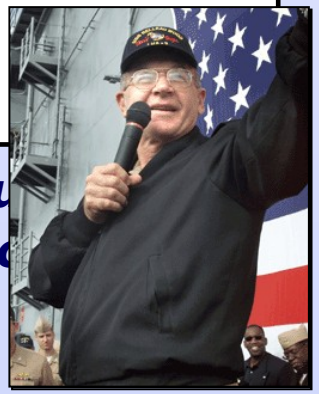
INCREASING FOCUS ON UNMANNED VEHICLES

- **Guidance From The President:**
  - **Unmanned Vehicles** -- ***"Now it is clear the military d***
    not have enough unmanned vehicles.
    entering an era in which un
    vehicles of all kinds will take
    greater importance -- in space, on land, in the air,
    and at sea."

    President's Address at The Citadel, Dec. 2001

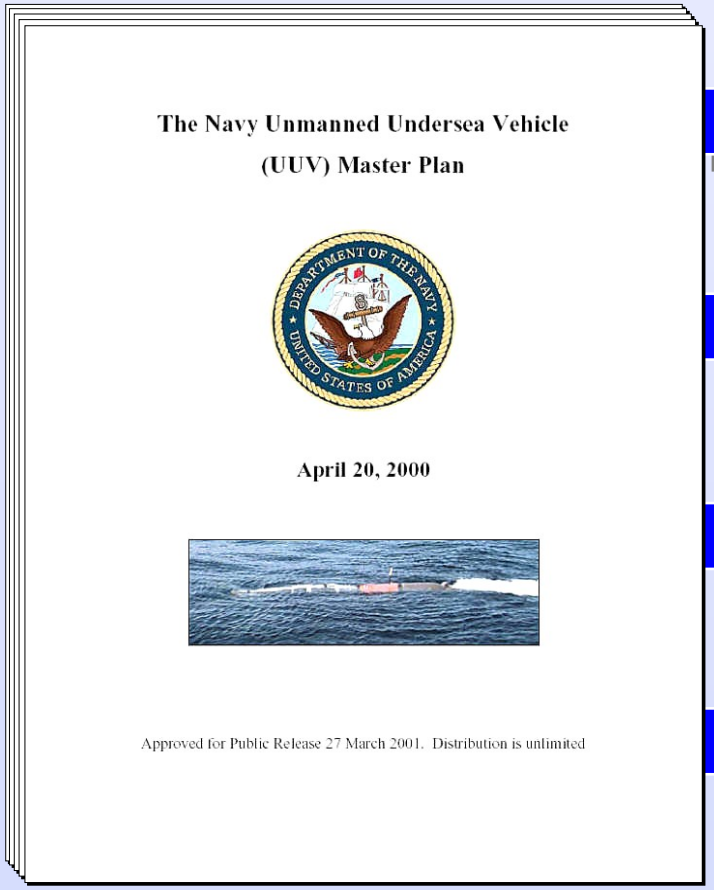


- **Guidance From The Chief Of Naval Operations:**
  - **Sea Shield** -- ***"Accelerate the developme***
    of sea-based unmann
    operate i
    environment."
  - **Future Readiness** -- ***"Accelerate***
    prototyping and experimentation
    of autonomous and semi-autonomou
    naval unmanned vehic



CNO Guidance For 2004

NAVY GUIDANCE FOR UUV DEVELOPMENT


The Navy Unmanned Undersea Vehicle (UUV) Master Plan

April 20, 2000

Approved for Public Release 27 March 2001. Distribution is unlimited

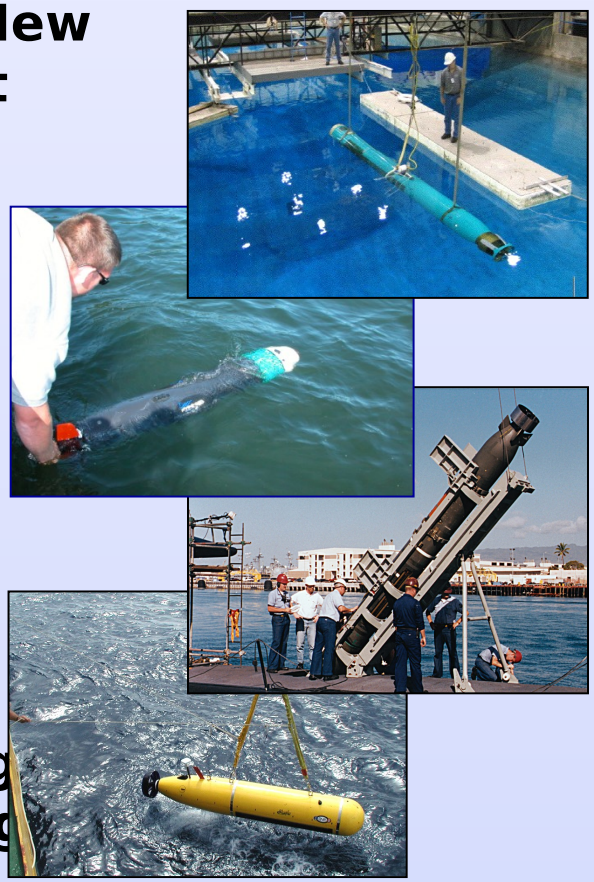
- Maritime Reconnaissance
- Undersea Search and Survey
- Communications / NAVAIDs
- Submarine Track and Trail

→ Future Capabilities For UUVs

The April 2000 *Navy UUV Master Plan* (Now Being Updated) Provided An Excellent Development Roadmap, But It Was Not Intended To Address T&E Needs Or Solutions

UUVS ARE RAPIDLY MATURING - *TESTING CAPABILITIES MUST ALSO MATURE* -

- **UUV Technology Research Is Yielding New Capabilities For Transition To The Fleet**
- **Several Acquisition Programs Are Underway For Fleet UUV Systems**
- **The UUV Community Has Moved From Basic Demonstrations To Complex Tests, Spiral Development, & Fleet Exercises**
- **Evolving UUV Programs, & Testing During Fleet Exercises, Are Bring New Testing & Training Challenges**



& *Different* T&E and Training Support Resources Are Needed In Ord
perly Evaluate & Further Improve UUV & Sensor / Payload Capabilit

FULL SPECTRUM SUPPORT FOR UUV T&E

NAVSEA KEYPORT
Undersea Warfare Center Division

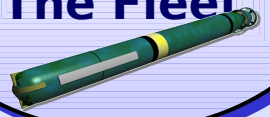
ONR Science & Technology

S&T and R&D:
- Few Formal Specifications
- Need Test System Flexibility
- Objective / "Ground Truth"

Shared, Standardized Resources Can Serve Multiple Program Requirements

Acquisition:
- Testing To Specifications
- "Requirements Compliance" T&E
- "User Operational Evaluation"
- DT / TECHEVAL / OPEVAL
- Production Acceptance Tests

Reliable **UUV Systems Available To The Fleet**



New Types Of Testing & Training Support Resources Are Required

In-Service:
- Verify Performance
- Check Repairs & Upgrades
- Mission Work-Ups
- Support UUV Cadre Training

A National Focus For Shared UUV T&E Solutions – *Across Programs; For All Levels Of Maturity; & For Training As Well As Testing* – Will Avoid Costs & Improve Results

EXAMPLES OF UUV TEST & EVALUATION CHALLENGES

- **Variety Of UUVs, Low Production Rates, Diversity Of Payloads, & Differing Test Requirements / Approaches**
  - ***Difficult To Achieve Economies Of Scale In Testing***
- **Lack Of "Ground Truth" & Standardization In Tests / Exercises**
  - ***Difficult To Make Comparisons & Technical Decisions On Performance***
- **Few Capabilities For Testing Multi-Vehicle Command & Control, Communications, Or Cooperative Behavior**
  - ***Difficult To Visualize & Control Multi-Vehicle Test / Exercise Activity***
  - ***Difficult To Gather Test / Exercise Data From Multiple Sources***
- **Limited Information On Test Site Characteristics And Limited Environmental Compliance Documentation**
  - ***Difficult To Determine Operationally Realistic Test Sites***
  - ***Expensive & Time-Consuming To Prepare NEPA Compliance Documentation***

Solving These Challenges Will Accelerate Fleet Delivery Of UUV Systems

NATIONAL UUV T&E CENTER (NUTEC)

- **Purpose: Leverage Weapon and UUV T&E Lessons Learned and Vehicle Support Expertise to Meet UUV Program Requirements**
  - **Build On Established Navy T&E Infrastructure & Experience**
  - **Provide New *UUV-Specific* Capabilities and In-Service Support**
- **Goal: Support UUV Developers, UUV Acquisition Programs, and th**
  - **Provide Robust, Shared, and Cost-Effective Capabilities**
    - ***In-Water and Land-Based T&E***
    - ***Fleet Training and Work-Up Suppo***
    - ***Vehicle Support***
  - **Provide *Anyplace, Anytime* T&E**

- **Approach: Coordination With UUV Stakeholders -- OPNAV, ONR, Acquisition Programs, Developers, Navy/University Labs, Test Facilities, NAVOCEANO, COMOPTEVFOR, & Fleet UUV Operational Units**

NUTEC'S PACIFIC NORTHWEST IN-WATER TEST AREAS

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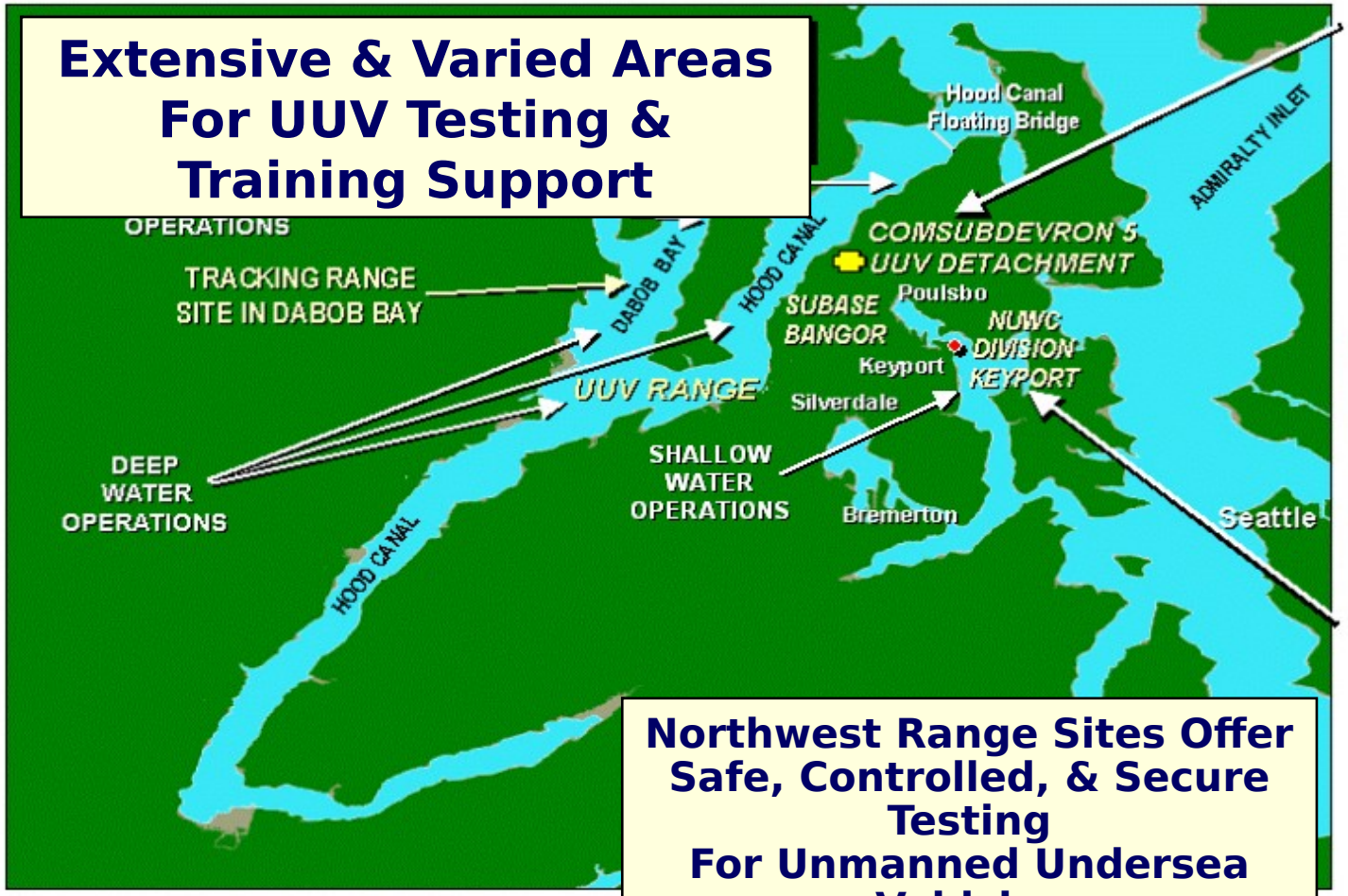
DEPARTMENT OF THE NAVY ONR Science & Technology

Extensive & Varied Areas For UUV Testing & Training Support



This Key NUTEC Test Area Is Co-Located With The Fleet's UUV Operations Cadres

Major Navy Test & Vehicle Support Infrastructure At Keyport

Northwest Range Sites Offer Safe, Controlled, & Secure Testing For Unmanned Undersea Vehicles

NUTEC'S Portable, UUV-Specific, T&E Capabilities Also Enable Testing At Sites Of Operational Interest World-Wide

AUTONOMOUS UNDERWATER VEHICLE (AUV) FEST 2003

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Undersea Warfare Center Division

NAVSEA NAVAL SEA SYSTEMS COMMAND Undersea Warfare Center

NAVAL METEOROLOGY AND OCEANOGRAPHY COMMAND

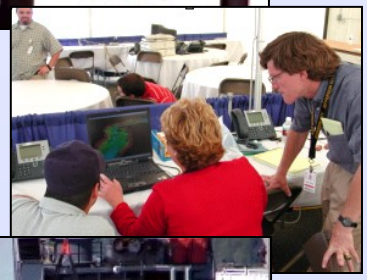
DEPARTMENT OF THE NAVY ONR Science & Technology

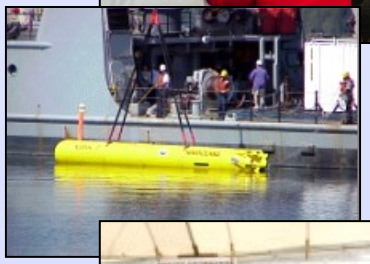
AUV Fest 2003 **-- An AUV / UUV Community T&E Event Focused On Spiral Development Testing & Work-Ups For 2004 Fleet Exercises**

March 2004

AUV FEST 2003 – A NEW APPROACH

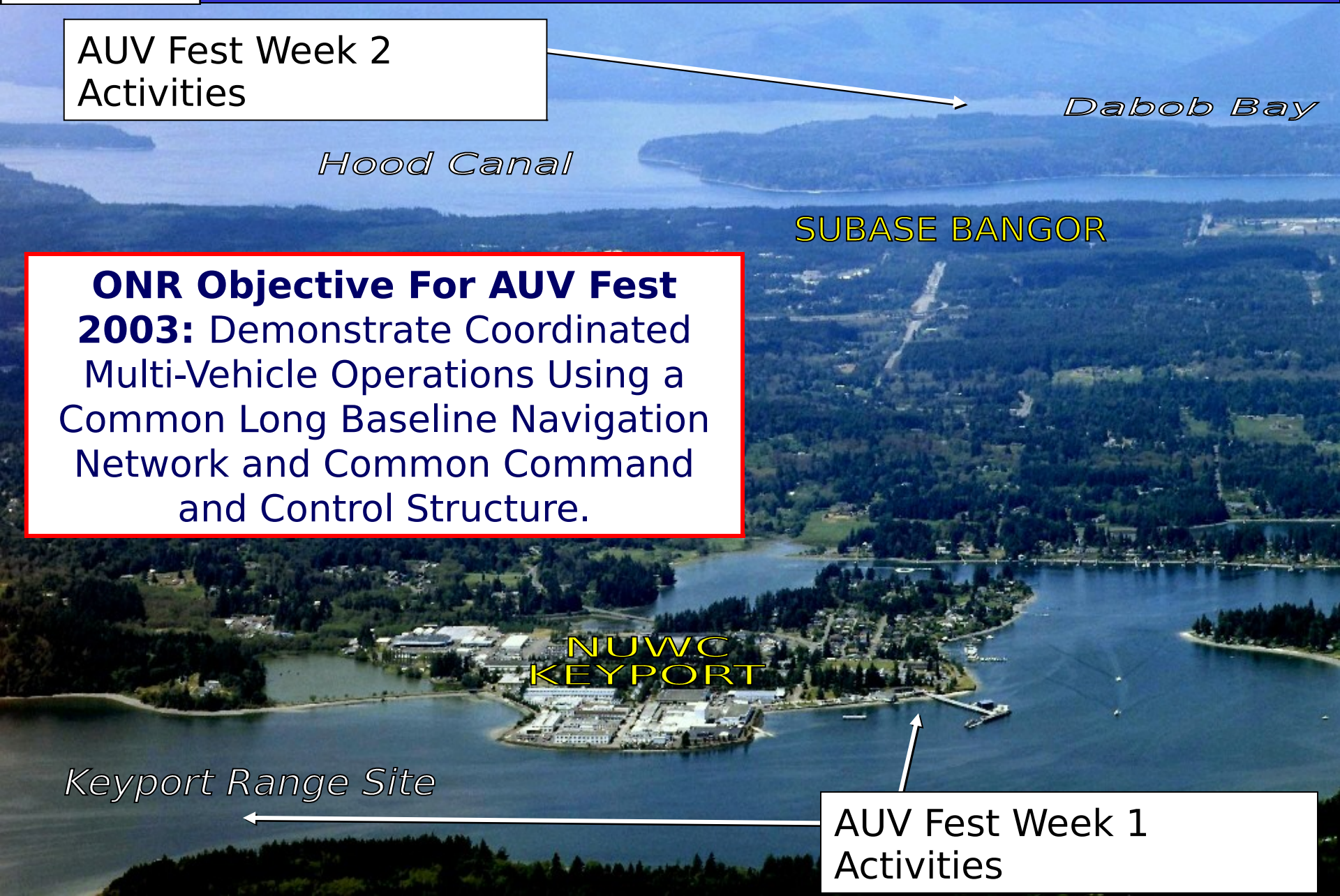
- **Co-Sponsored By ONR, CNMOC, & COMNUWC**
- **Hosted 11-22 August 2003 at NUTEC / Keyport**
- **New Focus: Work-Ups for Fleet Exercises**
- **In-Water Tests / Demos Plus On-Shore Activities**
  - **In-water Testing and Demonstrations at Keyport VSW Range Site & at Deeper Dabob Bay / Hood Canal Sites**
  - **UUV Testing and Training Workshops**
  - **Panel Discussion With Leaders & Key Decision Makers in AUV Community**
  - **Booths for Invited Organizations and Vendors to Demonstrate / Display Capabilities and Information of Interest to AUV Community**
- **294 Registered Attendees Representing Over 50 Organizations and 25 Vehicles**
- **Over 40 In-Water Test Events Conducted**





AUV FEST 2003 TEST LOCATION
NUTEC / NORTHWEST RANGE SITES

NAVSEA KEYPORT
Undersea Warfare Center Division



ONR Objective For AUV Fest 2003: Demonstrate Coordinated Multi-Vehicle Operations Using a Common Long Baseline Navigation Network and Common Command and Control Structure.

AUV FEST 2003 - OPERATIONS STAGING AREA

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DEPARTMENT OF THE NAVY ONR Science & Technology

Exhibit Area

Cyber Cafe

Remote Information Display Center

Convenient Vehicle Work Areas On Shore

Security Boat Moorings
ATF Barge
Parking
Rinse Tank
Static Displays
Cyber-Cafe
Command & Control
Remote Range Info Center
YTT
On Deck Circle
YP

Versatile Range Support Craft

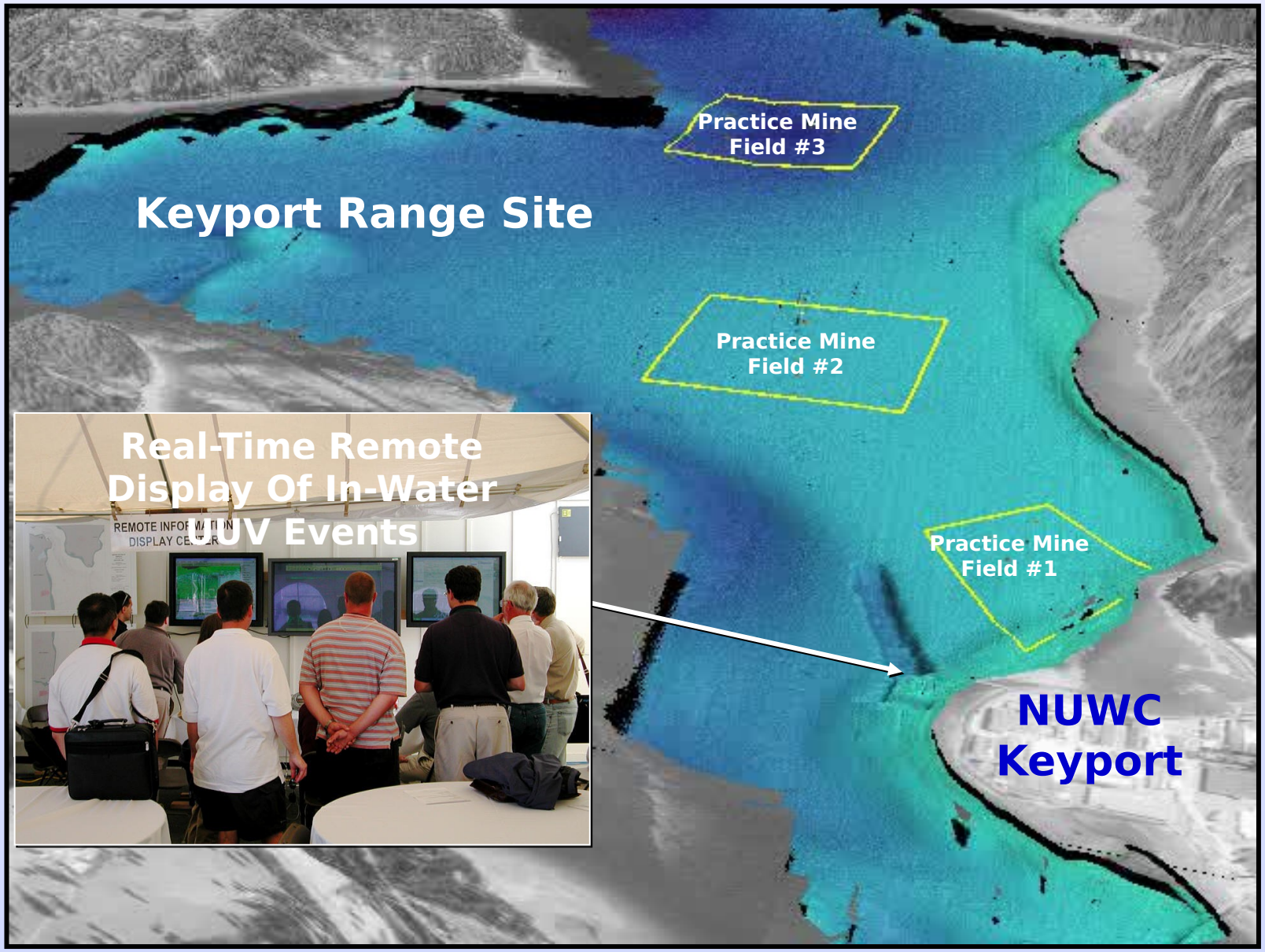
AUV Fest 2003

Cranes
Restrooms

WC Division Keyport, Washington

NAVSEA KEYPORT
Undersea Warfare Center Division

KEYPORT VSW RANGE SITE'S PRACTICE MINEFIELD LAYOUT FOR AUV FEST


Practice Mine Field #3
Keyport Range Site
Practice Mine Field #2
Real-Time Remote Display Of In-Water UUV Events
Practice Mine Field #1
NUWC Keyport

AUV FEST 2003 PARTICIPANTS -- ORGANIZATIONS & VEHICLE SYSTEMS --

NAVSEA KEYPORT
Undersea Warfare Center Division

- **PMS Naval Special Warfare / Hydroid, Inc.** — 2 SAHRV
  - EDM With Side Scan Classification Sc
  - EDM With DIDSON Classification Son

- **Woods Hole Oceanographic Institution** — 3 REMUS
  - S-C-M With 900 KHz Side Scan Sonar
  - DIDSON Classification Sonar
  - Optical Video Camera For Classification

- **NAVOCEANO** — 2 Seahorse
- **Lockheed Martin** — 4 CETUS II
  - Forward-Looking Sonar
  - Side Scan Sonar Version
  - Down-Looking Sonar Version

- **Naval Surface Warfare Center, Panama City / Perry Technologies** — 4 Crawlers
  - Simulated Neutralization Vehicle For Target Reac Neutralization
  - Classification Sonar
  - Land Crawler For Demonstrations
  - Camera For Visual Classification

- **Applied Physics Lab, Foster Miller** — 1 Seaglider
  - Seaglider Vehicle On Display In Booth
  - DIDSON Sonar

- **Nekton Research, Inc.** — 4 Rangers
  - In-water Demonstrations Near Pier

- **Univ. Of Washington**

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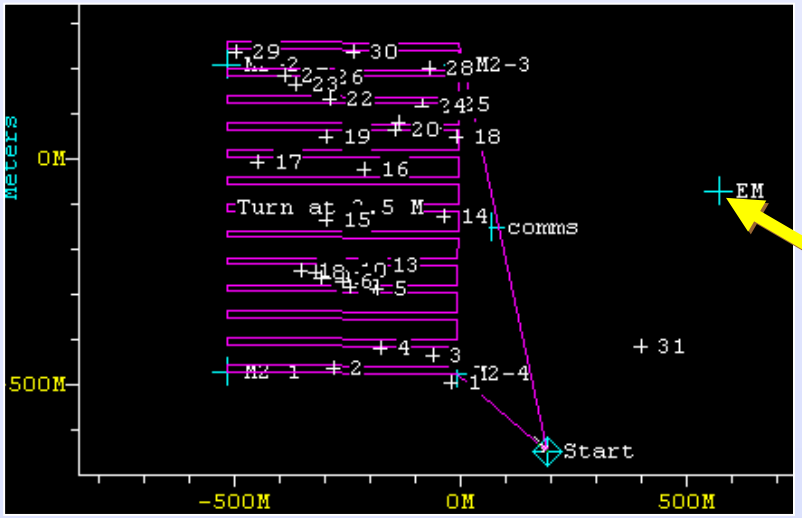
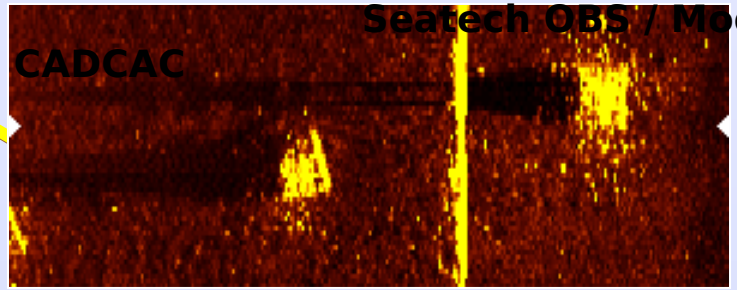
EXAMPLE OF AUV TEST ACTIVITY

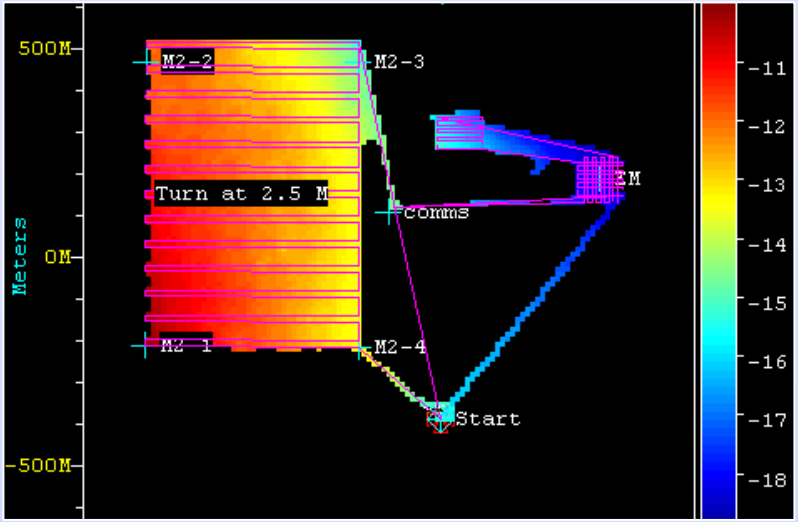
REMUS *DARTER* VEHICLE TEST



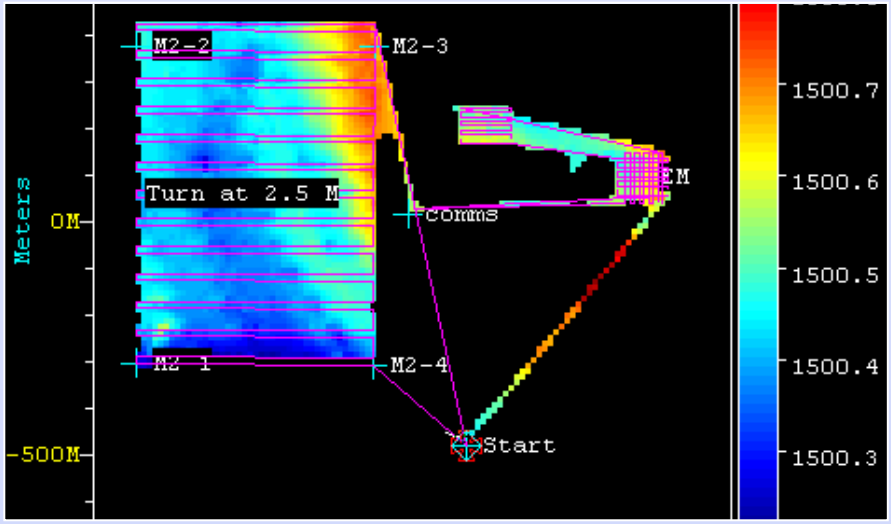
Date: 9 AUG 2003
Duration: 2:41:03.8
Distance Traveled: 10.49 Nmi
Power: 238 Watts Used
Instruments: ADCP / CTD / 900 KHz
Sidescan / **Seatech OBS / Modem /** **CADCAC**



EMFVM SENSOR ARRAY IMAGED BY REMUS



UUV'S BATHYMETRY MEASUREMENT



UUV'S SOUND SPEED MEASUREMENT

IN-WATER TEST OPERATIONS TEMPO EXAMPLE

Initial In-Water Schedule For AUV Fest Week 1

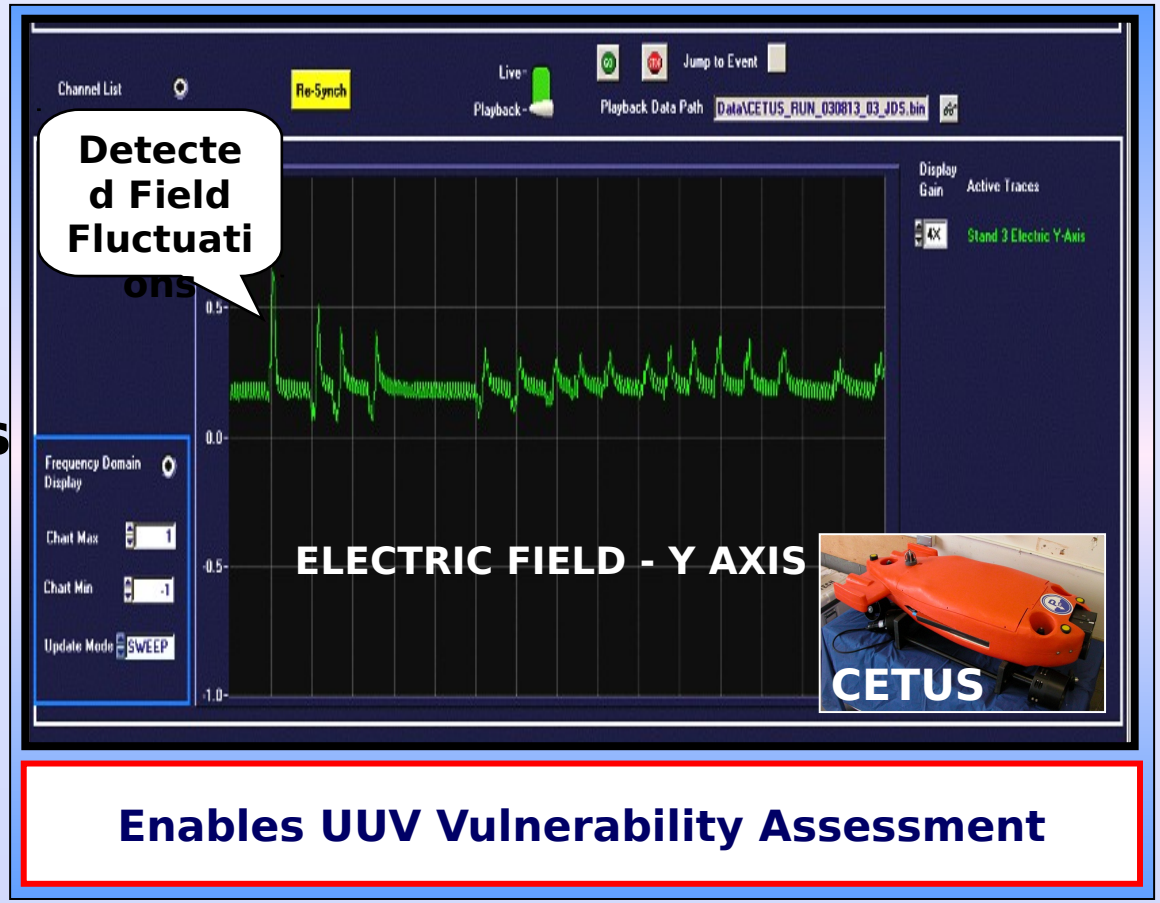
		Mine Area 1	Mine Area 2	Mine Area 3	EMF Area	Area C
August 11 Monday	AM	IN-WATER ASSIGNMENTS AS NEEDED				
	PM					
August 12 Tuesday	AM	REMUS + Crawler	SAHRV	SEAHORSE	CETUS	Crawlers
	PM	CETUS	REMUS	SEAHORSE	SAHRV	Crawlers
August 13 Wednesday	AM	SAHRV + Crawler	SEAHORSE	CETUS	REMUS	Crawlers
	PM	SAHRV	CETUS	REMUS	SEAHORSE	Crawlers
August 14 Thursday	AM	REMUS + CETUS	SAHRV	SEAHORSE		Crawlers
	PM	REMUS + CETUS	SAHRV	SEAHORSE		Crawlers
August 15 Friday	AM	TEAMS REACQUIRE AND CLASSIFY TARGETS BASED ON PREVIOUS RUNS				
	PM					

Up To 5 Simultaneous In-Water Events In Different Areas Of The Keyport Range Site

UUV ELECTRIC & MAGNETIC FIELD SIGNATURE MEASUREMENTS

- **T&E Capability: Measure UUV Electric & Magnetic Fields To Understand Their Signatures & Vulnerability**
- **UUV Signature**
  - **Electric Field**
  - **Magnetic Field**
  - **Acoustics**
- **Provide Systems**

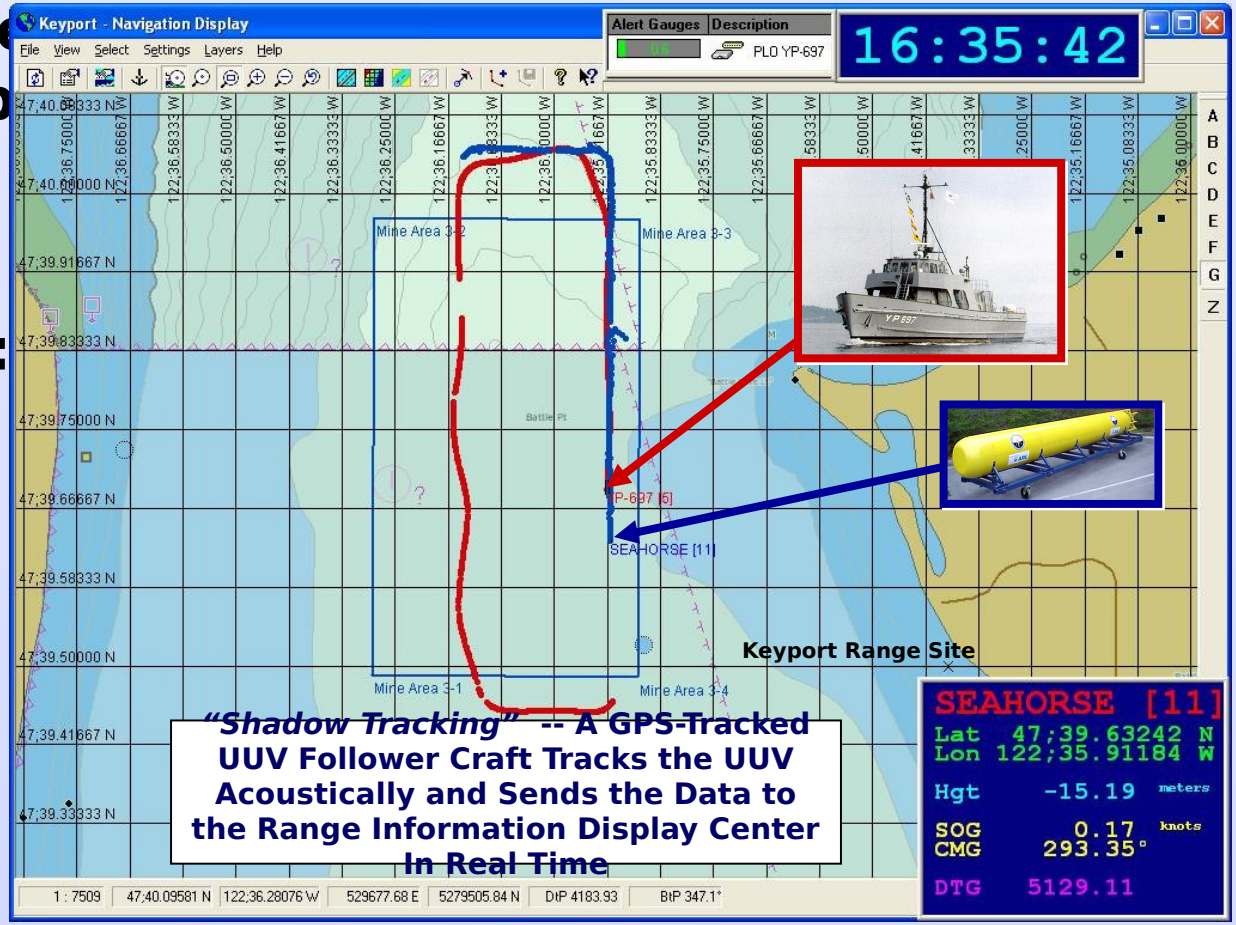
Measure The UUVs,



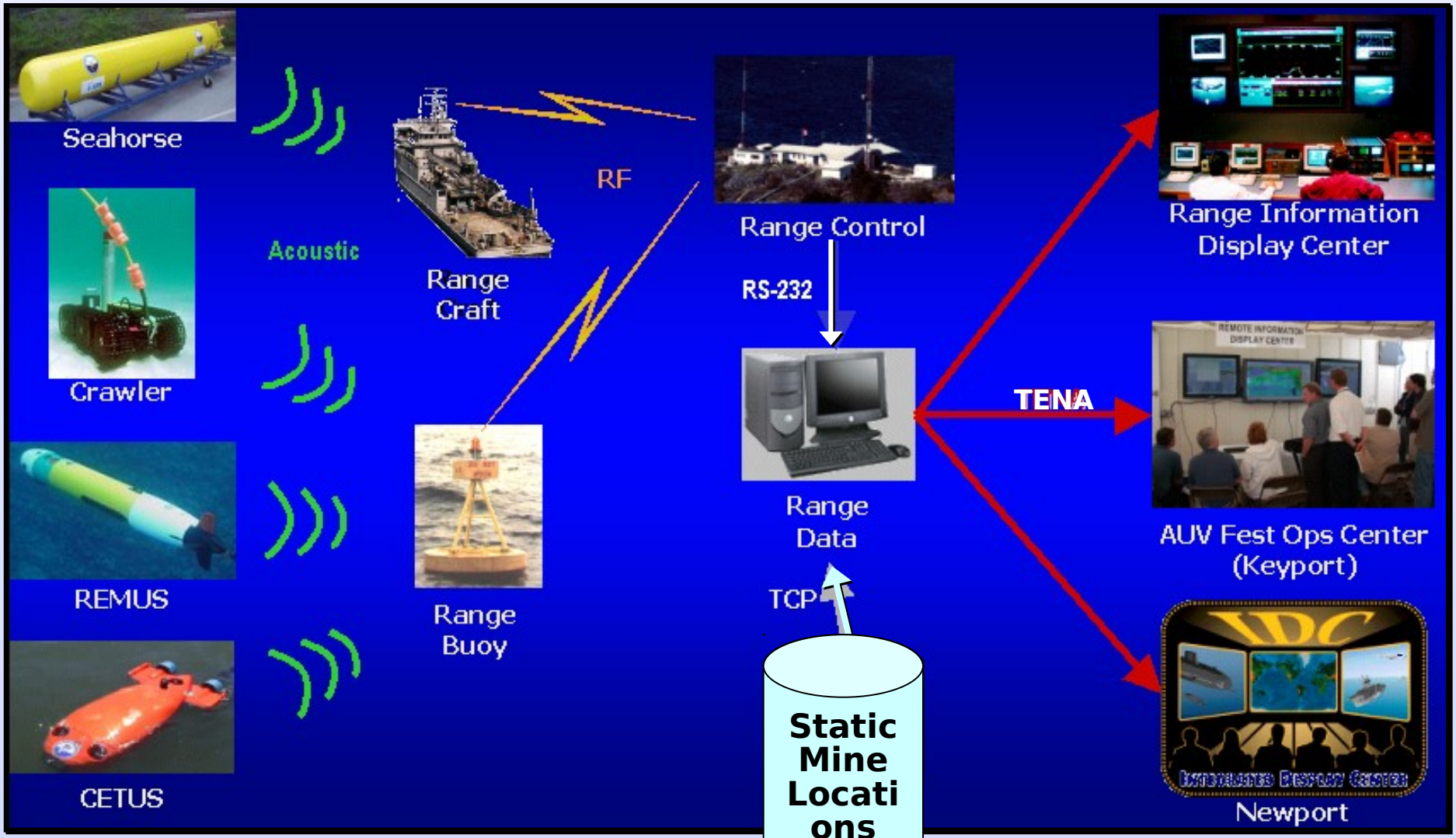
Enables UUV Vulnerability Assessment

WIDE-AREA UUV TRACKING

- **T&E Capability: Ground Truth Position Information For UUVs During Testing & Training Exercises**
- **A "Virtual Range" Anyp**
- **"Ground Truth" Track For:**
  - **Exercise**
  - **Safety**
  - **Recovery**
  - **Analysis**
- **Remote Display**



REAL-TIME DATA FLOW FOR AUV FEST EVENTS



AUV Fest Events Were Displayed In Real Time, Both Locally & At Remote Sites, Using NUTEC's TENA Compliant Time-Space-Position-Information (TSPI) Gateway

UUV & TEST SUPPORT CAPABILITIES DEMONSTRATED DURING AUV FEST 2003

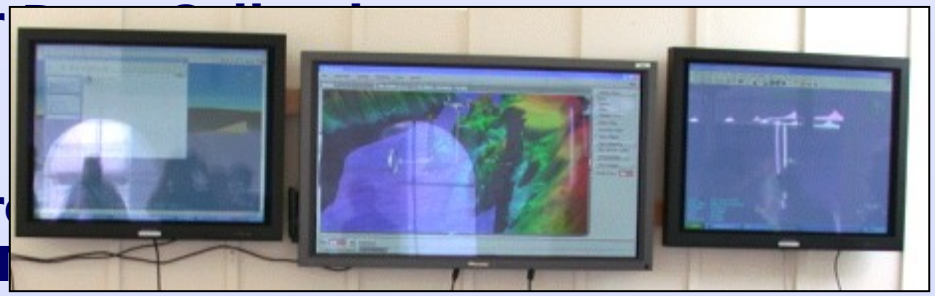
- **UUV Capabilities Demonstrated**
  - Multi-Vehicle Cooperative Behavior -- To Search, Classify, Reacquire, & Neutralize
  - Computer Aided Detection / Computer Aided Classification
  - Covert Minefield Detection
  - Multi-Vehicle Acoustic Communication Via WHOI Micro-Modems
  - Simulated Mine Neutralization
  - Precise Navigation
- **NUTEC Capabilities Demonstrated**
  - UUV “Shadow Tracking” With Remote Real-Time Displays
  - RF / Networked Data Connectivity For Test Support
  - TENA Gateway For Distributed Exercise Support
  - Ground-Truth-Characterized Practice Mine Fields
  - Integration Of Real-Time Track With Environmental Visualization
  - Enhanced Exercise & Environment Visualization Tools
  - Electric & Magnetic Field Measurements of UUVs

KEY AUV FEST CONCLUSIONS

- **Vehicle Programs Met ONR Test Objectives**
  - Demonstrated Communications & Cooperative Behavior Among Multiple Vehicles From Different Manufacturers
- **Workshops and Panel Discussion**
  - Identified UUV Community Frustration With Lack of Coherent Navy Strategy and Concept for Operations for UUVs
  - Technology Out-Pacing Navy Thinking and Planning
- **New NUTEC Capabilities Added Value to Test Events**
  - More “Ground Truth” Data: Environmental / Tracking / EMFVM
  - Well-Characterized Environment / Variety of Practice Minefields / Common Operational Picture Displayed in Real Time via TENA
- **Participants Enjoyed Easy Access to Demonstration Sites**
  - Nearby Shop Spaces / Large Pier / Support Craft / Logistics Support
- **Clear Requirements to Establish Standards for Testing, Comparison of UUV Systems, Communications, & Data Sets**
  - Need to Add Rigor, Ground Truth, and Formality to UUV Testing

FOLLOW-ON T&E SUPPORT FOR CJTFEX 04-2

- **Combined Joint Fleet Exercise (CJTFEX) 04-2 -- June 2004**
- **NUTEC's Portable Test Support Capabilities Will Provide A Common Operational Picture For CJTFEX UUV Events In the Very Shallow Water (VSW) Operations Area**
  - **Data Communications For In-Water**
  - **Large Screen Displays At Littoral Warfar Center (LWT**
  - **Acoustic Communications Data Monitoring / D**
  - **Environmental Information & Tracking Display**
  - **Live Streaming Video From Crawlers' Video Camera & DIDSON Imaging Sonar**



- **Remote Displays Elsewhere Can Be Accommodated**

THE WAY AHEAD

- **Update UUV Community T&E Requirements**
- **Provide New, UUV-Specific, Test and Training Capabilities**
  - **Focus On UUV Program Priorities For New T&E Solutions**
  - **Work With The UUV Community To Develop T&E Standards**
  - **Support The 2004 Update Of The Navy UUV Master Plan**
- **Planning For The Next AUV Fest**
  - **Potential Opportunities In Late Summer 2004 Or Spring 2005**
  - **NUTEC Focus: T&E To Help Participants Prepare For 2005 Fleet Exercises**
  - **CNMOC Focus: Rapid Environmental Characterization And Feedback For Operational Planning & Exercise Decision Making**
- **Increasing Support Required For Developmental & Operational Testing For Formal UUV Acquisition Programs**